DOCUMENT RESUME

ED 190 861 CE 026 432

TITLE	The Management of Building Environment for Comfort and Energy Conservation. Final Report.
INSTITUTION	North Seattle Community Coll., Wash.
SPONS AGENCY	Washington State Commission for Vocational Education, Olympia.
PUB DATE	80
NOTE	65p.: Some pages will not reproduce well due to light and broken type.
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	Behavioral Objectives: *Building Design: Buildings: *Climate Control: *Conservation Education: Course Descriptions: Curriculum: *Curriculum Development: Energy: *Energy Conservation: Environmental Education: Interior Design: Lesson Plans: Postsecondary Education: *Solar Radiation: Surveys: Two Year Colleges: Vocational Education
IDENTIFIERS	Environmental Control: Heat Pumps

ABSTRACT

This report presents materials from a Washington State project to develop a curriculum outline of three courses for energy conservation to be used in vocational supplement classes. It first presents results from an industrial survey on which engineers, architects, and mechanical contractors rated objectives for the three courses. Next are provided course descriptions and objectives for these courses: Indoor Environment and Energy Use, Energy Conservation through the Use of Heat Pumps, and Solar Heat as an Energy Source. The curriculum outline for The Management of Building Environment for Comfort and Energy Conservation contains an introduction, curriculum description, curriculum purpose, curriculum objectives, curriculum facilities, and curriculum administration. Course outlines for the three courses are presented in the following format: division, curriculum, course title, type of course, course description, course objectives, length of course, class size, prerequisites, required text, additional references, topical outline, and teaching plan outline. (YLB)

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ED190861

FINAL REPORT

Project No. 80-AJY(146)NN

THE MANAGEMENT OF BUILDING ENVIRONMENT FOR COMFORT AND ENERGY CONSERVATION

Curriculum Development Project
Conducted Under
Public Law 94-482

The project reported herein was performed pursuant to a grant from the Research Coordinating Unit of the Washington State Commission for Vocational Education. Contractors undertaking such projects under the Commission for Vocational Education sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Commission for Vocational Education position or policy.

Earl C. Weber,
Project Director
Developed by:
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May 1980

CE 026 432

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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PROJECT SUMMARY

Time Period:	Written between January 1, 1980 and June 15, 1980.
Objectives:	As listed in curriculum and course outlines.
Procedure Followed:	Outlined curriculum and courses, surveyed industry, completed program.
Results:	A complete curriculum of three courses for energy conservation to be used in vocational supplement classes, beginning Fall Quarter 1980.
Evaluation:	A valuable addition to the technology program of any school.
Conclusions:	Should be implemented not only as a supplemental, but also as vocational preparation classes. Could be a valuable addition to an HVAC program.

PROJECT SURVEY

May 28, 1980

Project: A new curriculum outline, for courses of study in:

"The Management of Building Environment for Comfort and Energy Management"

An industry survey was made, by mail, of 23 Engineers, Architects and mechanical contracors, who are all interested in the heating, ventilation and airconditioning industries, in order to get input to help develop meaningful objectives and outlines for the courses.

The survey included topical outlines for three courses, and general objectives for each. The parties surveyed were asked to rate the objectives, as good, adequate, or poor, and also requested to comment on the outlines.

Twenty three copies of the survey were mailed out, a copy is attached, and twenty were received back, marked and with comments. The results of the survey are re-capped on the attached copy of the survey form.

Developed by: Don Swenson, Instructor
North Seattle Community College
Seattle, Wash.

SURVEY RE-CAP May 28, 1980

INTRODUCTION

Due to the crisis in energy availability in our society, it is desirable that more people become knowledgeable about technologies concerned with energy conservation. This curriculum will be directed to those who are responsible for managing the environment in buildings.

The management of the environment in most of our larger buildings in this country is by equipment engineers who have the technical knowledge to operate the mechanical equipment, but not necessarily the knowledge to manage it most efficiently. The cost accounting responsibility for the management of these same buildings is normally a function of the accountants or business manager, who will have little or no understanding of the mechanical system in the building.

This curriculum is designed to help anyone involved in the management of environmental systems understand the general requirements of a comfort-providing system; the general application of equipment and systems to provide comfort; and to also understand what can be done with today's technology to achieve comfort levels in a building and still conserve energy.

Special emphasis is placed on heat-pumps and solar energy systems, as two developments which can be used in energy conservation in buildings.

TOPICAL OUTLINE OF COURSES

I. Indoor Environment and Energy Use
   - A. Building system management
   - B. Calculation of heating, cooling and ventilation loads
   - C. Environmental systems for commercial buildings
   - D. Environmental systems controls
   - E. System operating costs
   - F. Life cycle costs
   - G. Retrofit feasibility
   - H. Cost savings

II. Energy Conservation Through The Use of Heat Pumps
   - A. The refrigeration cycle
   - B. Reverse cycle
   - C. Components of the heat pump system
   - D. Operation of the system
   - E. Types of systems
   - F. Heat Reclaim
   - G. Solar assisted heat pump

III. Solar Heat As An Energy Source
   - A. Solar energy potential
   - B. Traditional uses
   - C. Availability
   - D. Collection systems
   - E. Heat storage
   - F. Distribution systems
   - G. Limitations of the solar systems

COURSE OBJECTIVES	Number of responses by category EVALUATION		
	Good	Adequate	Poor
Indoor Environment and Energy Use A course to provide the student with the basic knowledge of what the energy using systems are in the typical building: What environmental control systems are used, how to analyze the operation of the systems, and how to determine what can be done to improve the performance of the environmental control systems in the buildings.	18	2	0
Objectives 1.0 The student will show understanding of the different energy using systems in a typical building, and explain the interface between these systems in the maintenance of the building atmosphere.	16	3	0
2.0 The student will calculate the heating and cooling loads for a typical building, and interpret these loads in energy equivalents.	15	4	1
3.0 The student will describe a typical heating, cooling, ventilation system, and explain the operation of the components in the system.	15	4	0
4.0 The student will describe the typical control package used in an environmental control system.	15	4	0
5.0 The student will calculate the equipment operating costs, and relate them to life-cycle costs for the building.	15	5	0
6.0 The student will prepare a retrofit feasibility study, and an analysis of cost savings related to time.	17	3	0

COURSE OBJECTIVES	EVALUATION		
	Good	Adequate	Poor
Energy Conservation Through The Use of Heat Pumps A course to familiarize students with the operation of the heat pump, it's proper application and service, and it's energy saving potential when used as a heating service. It's use and application as a heat reclaim device and as a solar heating device will be covered.	17	3	0
Objectives 1.0 The student will describe the refrigeration cycle, and the typical components of a refrigeration systsm.	15	5	0
2.0 The student will describe a reverse-cycle system as used in a heat pump system.	16	4	0
3.0 The student will describe the requirements of a good heat pump installation, and operating characteristics of a properly operating system.	16	3	0
4.0 The student will analyze the cost-savings potential of a heat pump as compared to a conventional heating system.	15	4	0
5.0 The student will analyze the cost-savings possible in a heat-reclaim system using a heat pump on a typical ventilation system.	16	4	0
6.0 The student will understand what is meant by a solar-assisted heat pump system.	15	6	0

COURSE OBJECTIVES	EVALUATION		
	Good	Adequate	Poor
Solar Heat As An Energy Source A course to provide students with a knowledge of what solar energy is, how it can be used in a heating system, what the necessary components of a solar heating system are, and how to design and analyze a solar heating system for energy and cost savings.	18	2	0
Objectives 1.0 The student will calculate the solar energy potential for a given time and place.	16	3	0
2.0 The student will list the traditional methods of using solar energy for heating purposes.	15	4	1
3.0 The student will design a simple collection system.	15	4	0
4.0 The student will describe passive and active solar systems.	15	4	0
5.0 The student will design a simple solar system including the distribution system.	15	5	0
6.0 The student will analyze cost against savings for a typical solar heating system.	17	3	0

COURSE DESCRIPTIONS

Indoor Environment and Energy Use

A course to provide the student with the basic knowledge of what the energy using systems are in the typical building, what environmental control systems are used, how to analyze the operation of the systems, and how to determine what can be done to improve the performance of the environmental control systems in the buildings.

Energy Conservation Through The Use of Heat Pumps

A course to familiarize students with the operation of the heat pump, it's proper application and service, and it's energy saving potential when used as a heating device. It's use and application as a heat reclaim device and as a solar heating device will be covered.

Solar Heat as An Energy Source

A course to provide students with a knowledge of what solar energy is, how it can be used in a heating system, what the necessary components of a solar heating system are, and how to design and analyze a solar heating system for energy and cost savings.

COURSE OBJECTIVES

INDOOR ENVIRONMENT AND ENERGY USE

Objectives

1.0 The student will show understanding of the different energy-using systems in a typical building, and explain the interface between these systems in the maintenance of the building atmosphere.

2.0 The student will calculate the heating and cooling loads for a typical building and interpret those loads in energy equivalents.

3.0 The student will describe a typical heating, cooling, ventilation system, and explain the operation of the components in the system.

4.0 The student will describe the typical control package used in an environmental control system.

5.0 The student will calculate the equipment operating costs, and relate them to life-cycle costs for the building.

6.0 The student will prepare a retrofit feasibility study, and an analysis of cost saving related to time.

COURSE OBJECTIVES

ENERGY CONSERVATION THROUGH THE USE OF HEAT PUMPS

Objectives

1.0 The student will describe the refrigeration cycle, and the typical components of a refrigeration system.

2.0 The student will describe a reverse-cycle system as used in a heat pump system.

3.0 The student will describe the requirements of a good heat pump installation, and operating characteristics of a properly operating system.

4.0 The student will analyze the cost-savings potential of a heat pump as compared to a conventional heating system.

5.0 The student will analyze the cost-savings possible in a heat-reclaim system using a heat pump on a typical ventilation system.

6.0 The student will understand what is meant by a solar-assisted heat pump system.

COURSE OBJECTIVES

SOLAR HEAT AS AN ENERGY SOURCE

Objectives

1.0 The student will calculate the solar energy potential for a given time and place.

2.0 The student will list the traditional methods of using solar energy for heating purposes.

3.0 The student will describe the energy available from the solar source for time and place.

4.0 The student will design a simple collection system.

5.0 The student will describe passive and active solar systems.

6.0 The student will design a simple solar system including the distribution system.

7.0 The student will analyze cost against savings for a typical solar heating system.

A CURRICULUM OUTLINE

for a series of courses in

THE MANAGEMENT OF BUILDING ENVIRONMENT

FOR COMFORT AND ENERGY CONSERVATION

By; Don Swenson, Instructor

North Seattle Community College

Seattle, Washington

INTRODUCTION

Due to the crisis in energy availability in our society, it is desirable that more people become knowledgeable about technologies concerned with energy conservation. This curriculum will be directed to that objective.

The management of the environment in most of our larger buildings is by equipment engineers who have the technical knowledge to operate the mechanical equipment, but not necessarily the knowledge to manage it most efficiently. The cost accounting responsibility for the management of these same buildings is normally a function of the accountant or business manager, who has little or no understanding of the mechanical system in the building.

This curriculum is designed to help anyone involved in the management of environmental systems understand the general requirements of a comfort-providing system, the general application of equipment and systems to provide comfort, and to also understand what can be done with today's technology to achieve comfort levels in a building and still conserve energy.

Special emphasis is placed on heat-pumps and solar energy systems as two developments which can be used in energy conservation in buildings.

CURRICULUM DESCRIPTION

This curriculum, consisting of various courses to be taught in a sequence of three quarters, will provide a community college level of education for those interested in energy conservation, as related to environmental control in existing or new buildings.

It includes outlines for courses which cover the mechanical systems used in buildings, control systems, ventilation, heat pumps, building system management, solar heat and other subjects allied to energy management.

It is structured so that the various courses can be used separately as courses of study, or as part of the total curriculum. It will also be possible to incorporate new material into the existing courses, or add courses as new developments or ideas come forth in the energy management field.

CURRICULUM PURPOSE

Because of our dependence upon energy sources which are becoming more difficult to obtain and more costly, it becomes necessary to conserve energy in the heating and cooling of our buildings, and to accomplish this without sacrificing comfort for the occupants.

Maintaining reasonable levels of comfort as related to temperature, humidity, fresh air and circulation is both desirable and necessary for the well-being of building occupants. Proper control of these factors can make it possible to achieve comfort standards and still save energy. Mechanical equipment operators who are knowledgeable about both systems and energy conservation can achieve both goals. Unfortunately, many of our building managers are not now trained to achieve these goals.

This curriculum will make information available to those in our communities who are now working as operating engineers or as building or property managers, or those who may want to enter these fields, to make them knowledgeable in the areas that will enable them to manage systems in such a way that comfort conditions can be provided and yet energy can be conserved in the process.

The need for such trained personnel exists on both a national and local level. Many of the people presently employed as equipment operators have mechanical ability but not the technical knowledge to save energy. This curriculum will provide that knowledge.

CURRICULUM OBJECTIVES

Objectives in the individual course outlines will define the specific skill and knowledge goals to be attained by each student. This statement applies to the curriculum as a whole and will define general goals.

Each student who successfully completes the courses in the curriculum will be able to qualitatively evaluate the environmental control systems in a building and quanitatively evaluate the costs of operation; also they will be able to determine what changes should be made to decrease the energy consumption in the building.

1. The students will be able to analyze heating air conditioning and ventilation systems, to determine comfort levels and cost of operation.
2. Students will be able to describe and design control systems, and show mathematically, improvements in comfort and cost of operations due to changes in systems.
3. Students will be able to design a simple heat pump system, and to analyze cost savings due to heat pump use.
4. Students will be able to calculate solar energy available for heating purposes, and design a basic solar heat system, a solar assisted heating system, and a solar heat recovery system.
5. Students will be able to show mathematically the cost savings due to the use of solar energy for space heating and for water heating.

6. The students will be able to estimate system first costs, and life costs and compare the two for cost savings.

CURRICULUM FACILITIES

The physical facilities for the teaching of this curriculum shall be designed and organized to facilitate the acquiring of technical knowledge and the application of that knowledge.

1. Classroom: The classroom shall be an integral part of the laboratory, used for application problems. It must have seating capacity for a class not to exceed 24 students.
2. Laboratory: The laboratory must have room for 24 students to work on all trainers or operating equipment, either individually or in teams not to exceed 4 people, without interference of one group by another. The laboratory should be provided with storage space for supportive soft ware for the courses and locking storage space for tools, instruments and training aids.
3. Training aids: The laboratory should be provided with an adequate supply of operative heating, ventilating and air-conditioning units that can be used for demonstration and operation. Trainers should be provided that simulate the operation of heating, ventilation and airconditioning equipment and components for the equipment, for demonstration and simulated operation of the components of the systems.
4. Audio-visual equipment: Projection and sound equipment should be available in the room for the use of films, slides, transparencies, records, tapes and cassettes for teaching purposes.

5. The room should have a good heating and airconditioning system, and be well ventilated by a mechanical system (not opening of doors or windows), as well as being lighted for classroom use.

CURRICULUM ADMINISTRATION

Since the main courses in this curriculum will be taught by one instructor, that individual must be knowledgeable in all aspects of the field, including both theoretical and practical knowledge, and also be able to instruct others in these aspects. An instructor with experience in the HVAC industry, as well as experience in industrial education is a must. The instructor must be able to organize the educational material, present it in an understandable way, and demonstrate the operation of the components of various systems as found in practice.

The curriculum is designed for the technically oriented high school graduate with a basic knowledge of mathematics, physics and enough English to write intelligent reports; or a person now working in the HVAC field with a working knowledge of heating and/or airconditioning equipment, with the same requirements for English. The students should be screened by a counselor before entrance into the program to determine their interest in the particular field.

Each class period should include time for instruction and lab. time for practice exercises. The instruction time should be lecture/discussion sessions devoted to information pertinent to the segment of the course being studied, and the laboratory exercises should coincide with the instruction, to reinforce the material being taught.

The lab exercises should:

1. Be individual projects, if possible.
2. Utilize operating equipment or training simulators, tools pertinent to the trades involved, instruments and devices normally used by technicians in the energy management field.
3. Be supervised by the instructor on a one-to-one basis.
4. Be by assignment and require written report upon completion.

Students shall be graded on their ability to assimilate the technical data as well as their mechanical ability to work with the equipment. In addition, consideration will be given to their interest and attitude toward the Energy Management Industry as a potential source of employment.

Grades will be based upon:

1. Attendance in class
2. Attitude and interest
3. Technical knowledge of subjects
4. Performance in labs

Because of the practical aspect of the lab experiments, safety will be emphasized through all of the courses in this curriculum. Protection against mechanical, chemical and electrical hazards will be taught in each course.

COURSE OUTLINE

DIVISION Engineering Technology

CURRICULUM Management of Building Environment for Comfort and Energy Conservation

COURSE TITLE Indoor Environment and Energy Use

COURSE NUMBER QUARTER HOURS CREDIT

TYPE OF COURSE Occupational Supplement

COURSE DESCRIPTION This course shall provide the student with a basic knowledge of the energy-using systems found in the typical building; what environmental control systems are used, in the building systems; how to analyze the operation of the systems; and how to determine what can be done to improve the performance of the environmental control systems. and equipment in the buildings.

COURSE OBJECTIVES Upon successful completion of this course the student will be able to:

1. Describe the different energy-using systems found in buildings, and explain the interface between the systems.
2. Estimate the heating and cooling loads for a typical buliding, and interpret those loads in energy equivalents.
3. Describe a typical heating, cooling, and ventilation system, and explain the operation of the components in the system.
4. Describe the typical control package used in an environmental control system.

5. Calculate the equipment operating costs, and relate them to life-cycle costs for the building.

6. Prepare a retrofit feasibility study, and an analysis of cost savings related to a time span.

LENGTH OF COURSE The course shall consist of 22 to 24 classes of approximately 2½ hours each, or a normal quarter with two classes a week.

CLASS SIZE A maximum of 24 students

PREREQUISITES None Required

REQUIRED TEXT Sheet Metal and Air Conditioning Contractors' National Association, Inc., Guidelines for Energy Conservation In Systems in New Buildings, SMACNA, Vienna Virginia

ADDITIONAL REFERENCES Gates, Massey and Robertson, Energy Conservation Program Guide for Industry and Commerce, U. S. Department of Commerce, Washington, D.C.

Total Energy Management, Federal Energy Administration, U. S. Department of Commerce, Washington, D.C.

MAJOR DIVISIONS The major divisions in this course shall each be a self-contained unit of instruction as follows:

		Approx. Clock Hours
1.	Building system management.	5
2.	Estimating heating/cooling loads.	10
3.	Environmental systems	10
4.	Environmental control systems	5
5.	System operating costs.	10
6.	Life cycle costs.	5
7.	Retrofit feasibility.	5
8.	Cost savings.	5
	TOTAL HOURS	55

OUTLINE DEVELOPED BY Don Swenson, Instructor, NSCC DATE May 28, 1980

TOPICAL OUTLINE

Division #1 Building Systems Management

I. Systems That Use Energy in a Building

- A. Environment
  - 1. Heating/cooling
  - 2. Ventilation
  - 3. Lighting
  - 4. Exhaust
- B. Processes
  - 1. Office equipment
  - 2. Manufacturing
  - 3. IBM/computer

II. Energy Plusses in a Building

- A. Heating
  - 1. Lights
  - 2. People
  - 3. Solar

III. Controlling Costs

- A. Building management
- B. Accounting

Division #2 Estimating Heating/Cooling Loads

I. Heat Loss/Gain

- A. Btuh
  - 1. Sensible
  - 2. Latent
- B. Perimeter loads
  - 1. Conduction
  - 2. Solar
  - 3. Orientation
- C. Internal loads
  - 1. People
  - 2. Lights
  - 3. Equipment
- D. Ventilation
  - 1. Fresh air load

II. Load Calculations

- A. Procedure
  - 1. Temperatures
  - 2. Factors
  - 3. Forms

Division #3 Environmental Control Systems

I. Heating
   - A. Hot water
     1. Perimeter
        a. Radiation
        b. Convection
     2. Interior
        a. Blower coils
   - B. Warm air
     1. Duct heaters

II. Airconditioning
   - A. Chilled water
     1. Blower coils
   - B. California heat pump
     1. Load diversification

III. Ventilation system
   - A. Fresh air
   - B. Return air
   - C. Damper package
     1. Economizer for cooling
     2. Heat recovery

IV. Exhaust Systems
   - A. Comfort
   - B. Contaminated areas

Division #4 Environmental System Controls

I. Comfort Controls
   - A. Heating/cooling
     1. Temperature
     2. Humidity
   - B. Ventilation
     1. Fresh air
     2. Clean air

II. Types of Systems
   - A. Pneumatic
   - B. Electric
   - C. Electronic

D. Common Features
   1. Sensor
   2. Signal
   3. Controller
   4. Feed-back

III. Economizer Controls
   A. Time clocks
   B. Ventilation
   C. Load diversification

Division #5 System Operating Costs

I. Total Building Operation Costs
   A. Non-HVAC
      1. Lights
      2. Plumbing
      3. Janitorial
   B. HVAC
      1. Heating
      2. Cooling
      3. Ventilation

II. Costs Related To Environment/HVAC
   A. Daily
      1. Occupied
      2. Non-occupied
   B. Monthly
   C. Annual
   D. Zoning

Division #6 Life-cycle Costs

I. Equipment Costs
   A. HVAC
      1. Heating
      2. Cooling
      3. Ventilation
      4. Controls
   B. Related
      1. Power wiring
      2. Plumbing
      3. Waste water
   C. Proper operation
      1. Installation
      2. Maintenance
      3. Control function

Division #7 Refrofit Feasibility

I. Analysis of Existing System
   - A. Mechanical equipment
     1. Heating
     2. Cooling
     3. Ventilation
     4. Controls

II. Comfort Standards
   - A. Environment
     1. Temperature
     2. Humidity
     3. Air quality

III. Equipment Performance
   - A. Comparison to standards
     1. Temperature
     2. Humidity
     3. Air

IV. Improvements
   - A. Mechanical
     1. Updating
     2. Replacement
     3. Addition
   - B. Controls
     1. Updating
     2. Replacement

Division #8 Cost Savings

I. Operation Costs
   - A. Analysis
     1. Monthly
     2. Annual

II. Retrofit Costs
   - A. HVAC
   - B. Other

III. Savings Analysis ($)
   - A. Short term
   - B. Long term

IV. Energy Savings
   - A. Short term
   - B. Long term

TEACHING PLAN OUTLINE

Course # _____ Name Indoor Environment and Energy Use

Major division # 1 Name Building System Management

cussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
Building systems that use energy Energy plusses in a building Controlling costs	1. How the different systems in a building use energy 2. Amount of energy systems use. 3. What are the energy saving factors 4. How to calc. the savings when changes are made	1. List the equip which uses energy in a typical bld'g 2. Calculate the energy use 3. Recommend improvements in the system	1. Records of energy use for a typical building 2. Forms for calculating 3. Equipment specifications	1. Analyze the energy use in an existing building 2. Itemize improvements that could be made 3. Analyzr cos savings

TEACHING PLAN OUTLINE

Course # _____ Name Indoor Environment and Energy Use

Major division # 2. Name Calculation of H/C Loads

ussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
Heat loss and gain Perimeter loads Internal loads Ventilation Load diversification Load calc's	1. Effect outside temp. has on b'ldg loads (winter and summer) 2. Effect of solar radiation on loads 3. Effect of internal loads 4. Ventilation loads 5. Effect of building orientation 6. How to calc. loads 7. Analyze diversification problems	1. Calculate conduction losses 2. Calc. solar radiation loads 3. Calc. internal loads 4. Calc. vent. loads 5. Figure total loads 6. Figure effect of load shifting	1. Design temp. tables 2. Factor tables 3. Calc. forms 4. Plans of a typical b'ldg	1. Calculate loads 2. Analyze shifting loads 3. Interpret loads in terms of energy

TEACHING PLAN OUTLINE

Course # _____ Name Indoor Environment and Energy Use

Major division # 3 Name Environmental Systems

ussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignment:
:omfort ystem leating :ooling 'entilation :xhaust	1. What a hydronic system is 2. What a warm air system is 3. Components of each system 4. How a fresh air/ventilation system works 5. How the control systems in a building work 6. How heat pumps can be used, especially for load diversification	1. Design a simple hydronic system 2. Design a simple warm air system 3. Design a simple heat/vent system 4. Design a simple control package	1. Operating units 2. Duct system 3. Damper p'kg trainers 4. Control p'kg trainer 5. Example jobs to figure	1, Design various systems 2. Analyze operation of an existing system

TEACHING PLAN OUTLINE

Course # _____ Name Indoor Environment and Energy Use

Major division # 4 Name Environmental Control Systems

ussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignmen
Comfort systems controls Types of control systems Economizer controls Diversif-ication control systems	1. How a typical control system works 2. How unit control works 3. How the vent. system controls fit in with the system control 4. How re-heat is controlled 5. How load diversif-ication is accomplished	1. Read diagrams of typical control systems 2. Explain the operation of the typical control schemes 3. Analyze the performance of a econ-omizer p'kg 4. Calculate the savings estimated by using diff. types of systems	1. Controls 2. Control system simulators 3. Diagrams of typical systems 4. Damper p'kg simulators 5. System sim-ulators	1. Lab's o trainer 2. Identif ontro and ex-plain eration 3. Inspect existing jobs an analyze systems 4. Calc. savings

TEACHING PLAN OUTLINE

Course # _____ Name Indoor Environment and Energy Use

Major division # 5 Name System Operational Costs

ussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignment:
Non-Hvac cost of operations Hvac cost of operation Cost variations	1. Various operations in the building which are op.e-expense items 2. How to calc. operation costs for each 3. How to factor in variations due to load fluctuations	1. Gather data and figure costs 2. Calculate variations 3. Graph results	1. Access to an operating building 2. Cost data 3. Weather data 4. Calculation sheets	1. Gather data for calc's 2. Calculate costs 3. Graph the results 4. Analyze results an suggest ways to improve operation

TEACHING PLAN OUTLINE

Ccurse # _____ Name Indoor Environment and Energy Use

Major division # 6 Name Life Cycle Costs

:ussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignment:
Hvac equip't costs Other b'ldg system costs Equipment maintenance costs Building maintenance costs Total owning costs	1. H'tg/cooling equipment costs 2. Ventilation equipment costs 3. Electrical system costs 4. Janitorial system costs 5. Outside maintenance costs 6. Time factors	1. Gather data to figure all costs 2. Figure costs 3. Calculate offsetting factors 4. Construct break-down sheet of costs	1. Data on a typical b'ldg 2. Forms for calculations 3. Cost factors	1. Calculate all costs 2. Make a cost comp. chart 3. Construct a break-even chart for a typical b'ldg

TEACHING PLAN OUTLINE

Course # _____ Name Indoor Environment and Energy Use

Major division # 7 Name Retrofit Feasibility

ussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignment:
Analysis of an existing building Comfort standards Improvements	1. What systems in a building use energy 2. What equip't in the systems use energy 3. How to calc. amount of energy used 4. What are the comfort standards for a building 5. How to compare comfort standards with equipment performance 6. How to meet comfort standards and still save energy	1. Identify all systems which use energy in a building 2. Calculate am't of energy being used in a building 3. Define comfort standards 4. Analyze the operation of the systems in the b'ldg 5. Compare system operation with comfort standards 6. Re-design the systems or controls to save energy and still meet comfort standards	1. A building now in operation 2. Records of the building energy use 3. Cost data 4. List of standards	1. List all energy using systems in the building 2. Tabulate costs 3. Compare standards 4. Re-design 5. Analysis of expected savings

TEACHING PLAN OUTLINE

Course # _____ Name Indoor Environment and Energy Use

Major division # 8 Name Cost Savings

ussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignment
Operating costs Retrofit costs Dollar savings Energy savings	1. Operational costs 2. Cost effect on profitability 3. Energy use 4. Effect of maintenance in savings 5. How retrofit can save op. costs 6. How to predict savings in dollars and energy	1. Calculate cost of operation for various systems in the b'ldg 2. Chart costs and figure effect of variables 3. Calculate savings due to improvements in equipment or controls 4. Relate savings to dollars 5. Relate savings to energy	1. Data on an existing, operating b'ldg 2. Data on equip't in b'ldg and new equip't available 3. Calculation forms	1. Calculate costs on an existing b'ldg 2. Suggest improvemer in system or control 3. Plot savings for improved system 4. Show am't of energy saved

COURSE OUTLINE

DIVISION Engineering Technology

CURRICULUM Management of Building Environment for Comfort and Energy Conservation

COURSE TITLE Energy Conservation Through the Use of Heat Pumps

COURSE NUMBER QUARTER HOURS CREDIT

TYPE OF COURSE Occupational Supplement

COURSE DESCRIPTION This course will familiarize the student with the operation of the heat pump. It will cover it's proper application and service, and it's energy saving potential when used as a heating device. It's use and application as a heat reclaim device and as a component in a solar heating system will also be covered.

COURSE OBJECTIVES Upon successful completion of this course the student will be able to:

1. Describe the refrigeration cycle, and name the typical components of a refrigeration system.
2. Describe reverse-cycle refrigeration as used in a heat pump.
3. Describe the requirements of a good heat pump installation, and the operating characteristics of a properly operating system.
4. Analyze the cost-savings potential of a heat pump as compared to a convential heating system.
5. Analyze the cost-savings possible in a system using a heat pump as a heat-reclaim device, on a ventilation system.

6. Understand how a solar-assisted heat pump system works, and describe the component parts of such a system.

LENGTH OF COURSE The course shall consist of 22 to 24 classes of approximately 2½ hours each, or a normal quarter with two classes a week.

CLASS SIZE A maximum of 24 students.

PREREQUISITES None required

REQUIRED TEXT Harris and Conde, Modern Air Conditioning Practice, 2nd edition, McGraw Hill, New York, NY

ADDITIONAL REFERENCES Billy C. Langley, Comfort Heating, Reston Publishing, Reston, Virginia.

Althouse, Turnquist and Bracciano, Modern Refrigeration and Airconditioning, Goodheart-Wilcox, South Holland, Ill.

MAJOR DIVISIONS The major divisions in this course shall each be a self-contained unit of instruction as follows:

		Approx. Clock Hours
1.	The refrigeration cycle.	10
2.	Reverse cycle refrigeration system	5
3.	Components of the heat pump system	7½
4.	Operation of the system.	10
5.	Types of systems	5
6.	Heat reclaim	2½
7.	Solar assisted heat pump	5½
8.	Costs, and cost savings.	10
	TOTAL HOURS	55

OUTLINE DEVELOPED BY Don Swenson
Instructor NSCC

DATE May 28, 1980

TOPICAL OUTLINE

Division #1 Refrigeration Cycle

I. Heat
   - A. Specific, latent and sensible
     1. Temperature
     2. Heat
     3. Enthalpy

II. Pressure and Temperature
   - A. Change of state
     1. Boiling point temperature
     2. Enthalpy

III. Refrigerants
   - A. Physical properties
   - B. Boiling point temperature
     1. Enthalpy

IV. Components in an A.C. System
   - A. Operating
     1. Evap.
     2. Cond.
     3. Compressor
     4. Expansion device
   - B. Controls
     1. Power
     2. Operating
     3. Safety

Division #2 Reverse Cycle Refrigeration

I. Refrigeration Cycle
   - A. Heat of rejection
   - B. C.O.P
     1. Heat of rejection
     2. Heat of compression

II. Reverse Cycle Components
   - A. Heat from outdoors
   - B. Rejecting heat outdoors
   - C. C.O.P.

Division #3 Components of the System

I. Refrigeration Components
   A. Mechanical
   B. Reversing valve
      1. Construction
      2. Operation
   C. Expansion devices
      1. Check valves
      2. By-pass
   D. Refrigerant flow
   E. Controls
      1. Thermostat
      2. Defrost
      3. Low ambient

II. Auxiliary Heat
   A. Components
   B. Controls

Division #4 Operation of the System

I. Operating Pressure and Temperature
   A. Outside unit
   B. Inside unit
      1. Coil temperatures
      2. Air temperatures
         a. Air quantity

II. Defrost
   A. Temperature
   B. Controls
      1. Time
      2. Pressure

III. Auxiliary Heat
   A. Physical arrangements
   B. Control

IV. Efficient Operation

Division #5 Types of Systems

I. Air
   A. Split
   B. Package
      1. Outside

II. Water
   A. Package
      1. Free-standing
      2. Blower coil
      3. California system

Division #6 Heat Reclaim

I. Physical
   A. Exhaust system
   B. Supply system
   C. Controls

II. Operation
   A. Exhaust temperature
      1. Outside coil temperature
   B. Supply air temperatures
      1. Inside coil temperatures

III. Cost Savings

Division #7 Solar Assisted Heat Pump

I. Solar Heating
   A. Collection system
   B. Storage

II. Heat Pump With Solar Assistance
   A. System design
   B. Operation
   C. Cost savings

Division #8 Costs and Cost Savings

I. Installed Costs
   A. Heating

B. Heating and cooling

C. Auxiliary heat
   1. Electric
   2. Other

II. Operating Costs

A. Fuel costs

B. C.O.P.

C. Maintenance

D. Annual costs

III. Savings Analysis

A. Monthly

B. Annual

C. Energy savings

TEACHING PLAN OUTLINE

Course # _____ Name Energy Conservation with Heat Pumps

Major division # 1 Name The Refrigeration Cycle

scussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
Heat Pressure and temperature Refrigerants Components of a heat pump system Controls	1. Sensible heat 2. Latent heat 3. Change of state 4. Properties of refrig. 5. Major components of refrig system 6. Reverse cycle operation 7. Control systems	1. Identify major parts of a system 2. Graph temp/ enthalpy changes 3. Describe and draw a reversing valve in the system 4. Draw a wiring diagram of a typical control system	1. Data on refrigerants 2. Molier charts 3. Diagrams of systems 4. Operating heat pump 5. Wiring diagram of unit	1. Graph P/T and H 2. Draw an ideal cycle on Molier chart 3. Draw a sch. diagram of system 4. Draw a WD of a typ. system

TEACHING PLAN OUTLINE

Course # _____ Name Energy Conservation with Heat Pumps

Major division # 2 Name Reverse Cycle Refrigeration

cussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
Refrigeration cycle Reverse cycle refrigeration Special components Special controls C.O.P.	1. How the refrig cycle works 2. How the rev. cycle works to pick-up heat 3. How the system works 4. What controls are req'd with a heat pump 5. Efficiency of the heat pump	1. Analyze the operation of a heat pump 2. Identify and describe specific controls and components used on HP's 3. Graph the operation to identify efficiency	1. Operating units 2. Diagram of systems 3. Graph's for balance point curves	1. Describe system operation 2. Draw a diagram of system and write a sequence of operation 3. Plot a balance point curve against a building heat loss

TEACHING PLAN OUTLINE

Course # _____ Name Energy Conservation with Heat Pumps

Major division # 3 Name Components of the System

cussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
Refrigeration system components Reversing valve Expansion devices Refrigerant flow Controls Auxiliary heat	1. Typical refrigeration system 2. How a reversing valve works 3. What the reverse flow of refrig. does in the system 4. How expansion in either direction is achieved 5. Why a defrost control is necessary 6. Why auxiliary heat is requ'd	1. Analyze operation of a refrigeration system 2. Trace the refrigerant flow in a reverse cycle 3. Analyze a defrost control cycle 4. Idnetify all components in a HP system 5. Identify the auxiliary heat component in a system	1. Operating heat pump 2. Reversing valve simulator 3. Defrost control WD	1. Draw a typical Refrig system w/ components 2. Add HP components to above 3. Analyze operation of system including defrost controls

TEACHING PLAN OUTLINE

Course # _____ Name Energy Conservation with Heat Pumps

Major division # 4 Name Operation of a Heat Pump

scussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
Operating pressure and temps Defrost cycle Auxiliary heat Efficiency	1. How to use Molier chart to analyze efficiency 2. Effect of defrost cycle on efficiency 3. How to stage auxiliary heat	1. Calculate efficiency at various operating modes. 2. Analyze op of controls, especially defrost. 3.	1. Operating unit 2. Molier charts 3. Instruments for readings	1. Operate trainer 2. Graph efficiency 3. Analyze the operating modes

TEACHING PLAN OUTLINE

Course # _____ Name Energy Conservation with Heat Pumps

Major division # 5 Name Types of Systems

cussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments:
Air systems Water systems Physical types	1. Air to air 2. Air to water 3. Water to air 4. Water to water 5. Splits 6. Package	1. Identify types by air/water 2. List components of split system 3. List components of package unit	1. Operating units 2. O'heads of various types of units	1. Identify units on jobs 2. Identify in catalogs 3. Select unit for specific application

TEACHING PLAN OUTLINE

Course # _____ Name Energy Conservation with Heat Pumps

Major division # 6 Name Heat Reclaim

cussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignment:
Vhat it is? Types of systems Heat pump use. Cost savings	1. How a heat reclaim system works 2. When to use one 3. How a HP can be used for heat reclaim. 4. What it will save in $ 5. What it will save in energy	1. Design a simple recovery system 2. Analyze feasibility 3. Calculate savings a. In $ b. In energy	1. Plans of a building system needing reclaim 2. Instruments 3. Cost data on operation	1. Analyze need 2. Design a system 3. Figure savings

TEACHING PLAN OUTLINE

Course # _____ Name Energy Conservation with Heat Pumps

Major division # 7 Name Solar Assisted Heat Pump

cussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignment:
Solar heating Heat pump with solar system	1. Fundamentals of solar heating 2. How HP is used with solar system 3. Cost savings potential	1. Design a simple system 2. Analyze cost savings	1. Design data	1. Design a simple system

TEACHING PLAN OUTLINE

Course # _____ Name Energy Conservation with Heat Pumps

Major division # 8 Name Costs and Savings

cussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignment:
Installed costs Operating costs Savings analysis In $ In energy	1. How to estimate job costs 2. How to analyze operating costs 3. How to graph costs to compare savings	1. Estimate costs for equipment and labor 2. Calculate operating costs 3. Plot costs of various systems and analyze	1. Cost data a. Equip't b. Operating 2. Analysis charts	1. Do a complete analyxis of costs

COURSE OUTLINE

DIVISION Engineering Technology

CURRICULUM Management of Building Environment for Comfort and Energy Conservation

COURSE TITLE Solar Heat as An Energy Source

COURSE NUMBER QUARTER-HOURS CREDIT

TYPE OF COURSE Occupational Supplement

COURSE DESCRIPTION This course shall provide the student with a practical knowledge of solar energy, traditional methods of using solar energy as a heat source, methods of calculating the availability of solar energy, design of collection systems, storage, distribution, hot water heating, and space heating; reasons for developing solar systems, and the limitations of solar energy for practical use.

COURSE OBJECTIVES Upon successful completion of the course the student will be able to:

1. Calculate the availability of solar energy, for a given time and place.
2. List the traditional methods of using solar energy for heating purposes.
3. Describe active and passive solar systems.
4. Design a simple collection system.
5. Design a total solar system, including the storage and distribution system.
6. Critically compare different types of systems.
7. Analyze cost savings, first and operating, of a solar heating system compared to a conventional system.

LENGTH OF COURSE The course shall consist of 22 to 24 classes of approximately 2½ hours each.

CLASS SIZE A maximum of 24 students

PREREQUISITES None required

REQUIRED TEXT U.S. Department of Commerce, Solar Heating and Cooling of Residential Buildings, Federal Energy Administration, Washington, D.C.

ADDITIONAL REFERENCES U.S. Department of Commerce, Total Energy Management, Federal Energy Administration, Washington, D.C.

Bell and Gossett, Solar Heating Systems Manual, ITT, Morton Grove, Ill.

Lennox Industries, Inc., Solar Heating, Fort Worth, Texas

Watson, Designing and Building a Solar House, Garden Way Publishing, Charlotte, VT.

MAJOR DIVISIONS The major divisions in this course shall each be a self-contained unit of instruction, as follows:

		Approx. Clock Hours
1.	Solar energy potential.	5
2.	Traditional uses of solar energy as a heat source.	2½
3.	Availability of solar energy.	10
4.	Collection systems.	12½
5.	Heat storage.	7½
6.	Distribution systems.	12½
7.	Limitations of the solar system	5
	TOTAL HOURS	55

OUTLINE DEVELOPED BY Don Swenson, Instructor NSCC DATE May 28, 1980

TOPICAL OUTLINE

Division #1 Solar Energy Potential

I. Solar Constant
   - A. Intensity of solar radiation-definition
   - B. Value
   - C. Orbital variations

II. Insolation
   - A. Solar energy to reach Earth's surface
     1. Ultra-violet radiation
     2. Short wave
     3. Reflection
   - B. Available radiation
     1. Direct
     2. Diffuse
     3. Reflected
   - C. Optimum conditions
     1. Variables

Division #2 Traditional Uses of Solar Energy

I. Living Quarters
   - A. Indian
     1. Orientation
     2. Ampitheatre effect
     3. Overhangs
   - B. Cave dwellings, European
   - C. New England salt-box houses
   - D. Early experimental houses
     1. Glass
     2. Orientation
     3. Passive collection

II. Commercial Use
   - A. Furnaces
     1. Archimedes
     2. Solar furnaces
   - B. Power
     1. Steam engine
     2. Hot air engines
     3. Solar batteries
     4. Solar collecters
     5. Solar powered irrigation

Division #3 Availability of Solar Energy

I. Solar Spectrum
   A. Solar energy identified by wave length
      1. High frequency-Ultraviolet
      2. Medium frequency-Visible
      3. Low frequency-Infrared

II. Variations Effecting Available Energy
   A. Atmosphere (see Division #1)
   B. Monthly
      1. Seasonal
   C. Angular incidence
      1. Horizontal
      2. Latitudinal
   D. Daily variations
      1. Atomopheric
   E. Hourly variations
      1. Rotation

III. Collector Tilt
   A. Angle of incidence
   B. Latitude

IV. Orientation
   A. Direction
   B. Sun tracking

Division #4 Collection Systems

I. What Is A Collector?
   A. Definition
   B. Types of collectors
      1. Liquid
      2. Air
   C. Flat plate collectors
      1. Construction
         a. Absorber
         b. Insulation
         c. Glass cover
         d. Collecting medium
      2. Operation
         a. Absorption
         b. Conduction loss
         c. Radiation loss

D. Efficiency
   1. Construction
   2. Solar intensity
   3. Orientation

II. Collector Area

A. Heating load
   1. Heat loss
   2. Degree days
   3. Heat loss/month

B. Hot water load
   1. Temperature
   2. Consumption
   3. Btu/month

C. Total load by month

D. Load vs. collector area

Division #5 Storage Systems

I. Reason For Storage

A. Carry-over

II. Methods

A. Latent heat

B. Sensible
   1. Passive system
   2. Active system

III. Sizing Storage Capacity

A. Relative to heat load

B. Relative to collector size

IV. Storage As Part Of The Total System

A. Passive
   1. Location
   2. Control of temp

B. Active
   1. Relative to collectors
   2. Control
   3. As part of the water heating system

Division #6 Distribution Systems

I. The Total System
   A. Collectors
   B. Piping
   C. Storage
   D. Controls
   E. Auxiliary equipment
      1. Back-up heat
      2. Culinary water
      3. Heat rejection
   F. Circulation systems

Division #7 Limitations

I. Geographical Location
   A. Winter operation
      1. Available radiation
      2. Temperature
      3. Load
   B. Summer operation
      1. Load

II. Physical Size
   A. Collectors
   B. Storage

III. Cost
   A. First cost
      1. Collectors
      2. Storage
      3. Controls
      4. Auxiliary heat
   B. Operating costs
      1. Passive
      2. Active

IV. Energy Savings
   A. Comparisons
      1. Conventional systems
      2. Heatpump systems

TEACHING PLAN OUTLINE

Course # _____ Name Solar Heat as an Energy Source

Major division # 1 Name Solar Energy Potential

scussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
The solar constant Insolation	1. Intensity of of solar radiation in space 2. Direct factors effecting it's reaching Earth 3. Quantity reaching Earth 4. Variables effecting insolation	1. Calculate insolation for different times of year 2. Calculate insolation for angular variations	1. Insolation meter 2. Solar collector demonstration	1. Calculate insolation values 2. Measure Btuh by air and water temp. rise

TEACHING PLAN OUTLINE

Course # _____ Name Solar Heat as an Energy Source

Major division # 2 Name Traditional Uses of Solar Energy

scussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
Living quarters Commercial use	1. How orientation effects energy collection 2. Type of Effects 3. Passive system 4. Solar furnace 5. Solar batteries	1. Calculate effect of orientation 2. Calculate effect of shading 3. Calculate effect of insulation 4. List at least (5) uses for solar energy	1. House plans 2. Calculation forms 3. Text on solar heating	1. Calculate solar gain for house 2. Calculate passive solar stor. capacity 3. Calculate "R" for a wall and relate to heat gain or loss

TEACHING PLAN OUTLINE

Course # _____ Name Solar Heat as an Energy Source

Major division # 3 Name Availability of Solar Energy

ɔcussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
Solar spectrum Variations effecting insolation Collector efficiency	1. How the sun breaks down into diff. wavelengths 2. Variables effecting solar rays reaching the Earth 3. Collector efficiency variables	1. Analyze the rays of the sun in relation to heat 2. Calculate insolation for a given time and place 3. Calculate collector efficiency	1. Insolation tables 2. Solar tables 3. Data on collectors	1. Calculate insolation 2. Calculate collector efficiency 3. Relate the above to time

TEACHING PLAN OUTLINE

Course # _____ Name Solar Heat as an Energy Source

Major division # 4 Name Collection Systems

cussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
Type of systems Types of collectors Collector efficiency	1. Passive and active system collectors 2. Flat plate collectors 3. Concentrating collectors 4. Stationary and tracking collectors 5. Construction of flat plate collectors	1. Calculate comparative efficiency 2. Calculate optimum orientation for collector cells 3. Design a basic collector	1. Collector demonstrator 2. Factor tables 3. Collector spec's	1. Calculate efficiency of active and passive systems 2. Design a collector install'n for maximum efficiency

TEACHING PLAN OUTLINE

Course # _____ Name Solar Heat as an Energy Source

Major division # 5 Name Heat Storage

cussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
Reasons for storage Methods of storage Sizing a storage system	1. Why storage is necessary 2. Different types of storage 3. How to size storage facilities 4. How storage becomes a part of total system	1. Analyze job and choose type of storage 2. Size of storage facilities 3. Design storage facilities	1. Text on storage 2. Data on storage types 3. Calculation forms	1. Define proper stor for job 2. Calculate amount of storage required 3. Design storage facility

TEACHING PLAN OUTLINE

Course # _____ Name Solar Heat as an Energy Source

Major division # 6 Name Distribution Systems

cussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
The total system (combining the components) Getting the heat out into the building	1. How to combine the individual components to make a workable system 2. What part of the total h'tg load can be carried by the solar system 3. How to incorporate the auxiliary heat into the system. 4. How to design an actual distribution system	1. Design a total solar system 2. Calculate how much auxiliary heat is required 3. Design a control system 4. Design a distribution system	1. Recommended layouts for passive and active systems 2. Design data 3. Control system schematics	1. Draw a layout of a complete solar system 2. Calculate the amount of auxiliar heat req'd 3. Draw a layout of a distributio system 4. Draw a schematic of a control system

TEACHING PLAN OUTLINE

Course # _____ Name Solar Heat as an Energy Source

Major division # 7 Name Limitations to Solar Heat Systems

Discussion topic	Student should know:	Student should be able to do:	Instructional aids	Assignments
Geographical limitations Physical size Cost Energy savings	1. Solar energy availability varies with geographical location and climate 2. Collector size is limited to physical environment 3. Storage is limited by physical environment 4. Cost compared to savings 5. How much energy can actually be saved	1. Calculate percentage of Insolation at various locations 2. Evaluate collector system sizing 3. Evaluate storage capacities 4. Analyze $ costs 5. Analyze the energy savings	1. Data on energy availability 2. Data on system design 3. Data on costs of operation	1. Calculate the size of components for a job 2. Calculate the $ savings on operation 3. Calculate the energy savings on comparable jobs